

A Human-Autonomy Teaming Approach for a Flight-Following Task

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- Incidents and accidents result from pilots failing to understand increasingly sophisticated aircraft systems
 - These systems are often **brittle** and rarely degrade gracefully
 - Automation helps when all goes well but leaves the human **out-of-the-loop** when it fails
 - Automation interfaces often lack **transparency**, not facilitating understanding or tracking of the system
 - Disuse and misuse of automation (**miscalibrated trust**) have lead to real-world mishaps and tragedies
- Human involvement with increasingly sophisticated automated systems must adjust to allow for a more dynamic relationship involving cooperation and teamwork

- Part-task study to demonstrate, evaluate and refine proposed tenets of human-autonomy teaming (HAT)
 - Bi-directional communication
 - Transparency
 - Operator-directed interface
- Built on an earlier ground station to minimize development and focused primarily on interactions with one piece of software
- Overall goal is to develop a framework for HAT in aviation and provide guidelines and recommendations for its application

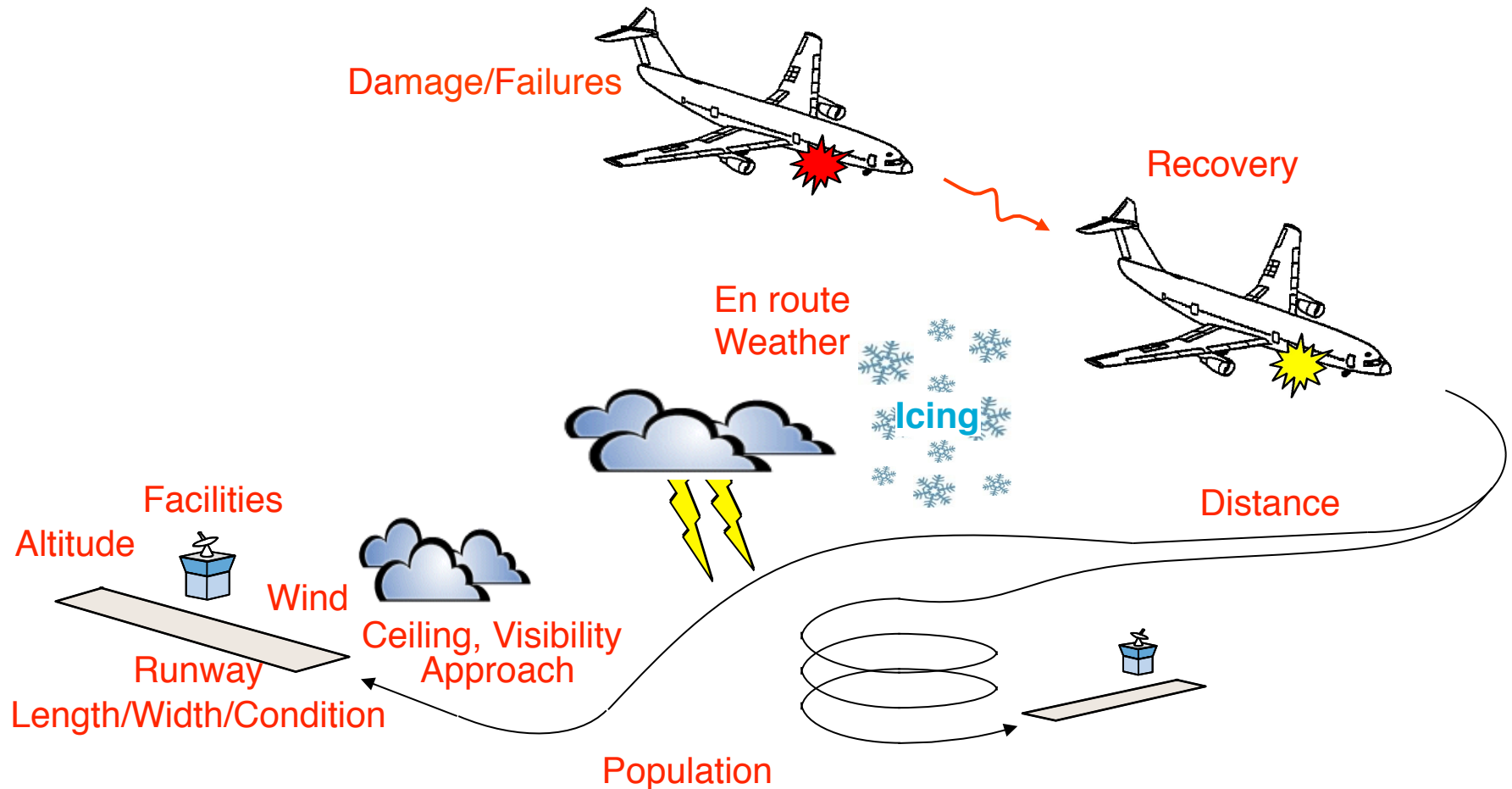
- Participants: 4 Dispatchers, 2 Pilots
- Participants, with the help of automation, monitored aircraft
 - Alerted pilots when
 - Aircraft was off path or pilot failed to comply with clearances
 - Significant weather events affect aircraft trajectory
 - Pilot failed to act on EICAS alerts
 - Rerouted aircraft when
 - Weather impacted the route
 - System failures or medical events force diversions
- Ran two ~50-min scenarios, containing approximately 40 aircraft and 6 off-nominal events
 - One scenario with HAT tools, one scenario without HAT tools

ELP: Emergency Landing Planner (2007-2012)

- Cockpit decision aid
- Route planning for (serious) emergencies
 - control system failures
 - physical damage
 - fires
- Time & safety were dominant considerations

ACFP: Autonomous Constrained Flight Planer (2013-2017)

- Ground station decision aid
- Diversion selection, route planning, route evaluation
 - weather diversion
 - medical emergencies
 - less critical system failures



**Find the best landing sites and routes
for the aircraft**

Emergency Page on the CDU

Runway length

Runway

Airport

Select

Principal Risks

Page #

Distance to airport

Bearing to airport

Show Airport Info Page

Update

Execute the selection

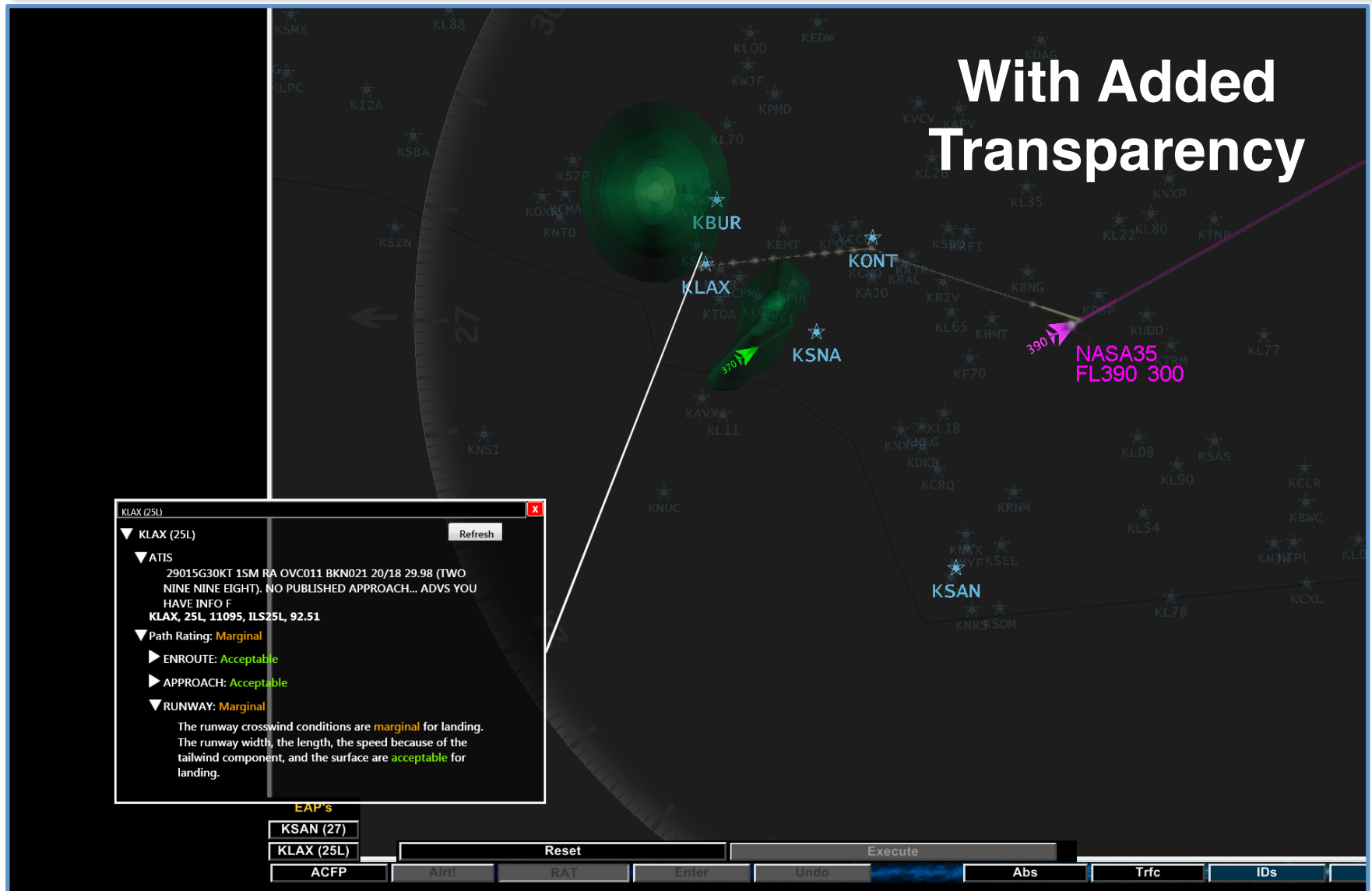
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Simulated Ground Station

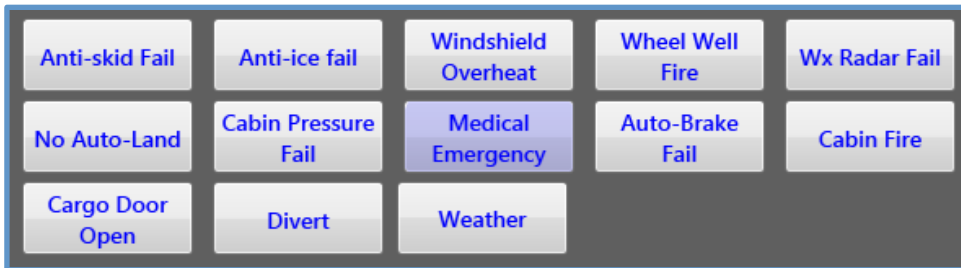


Building in HAT Tenets to the Ground Station **SJSU** SAN JOSÉ STATE UNIVERSITY

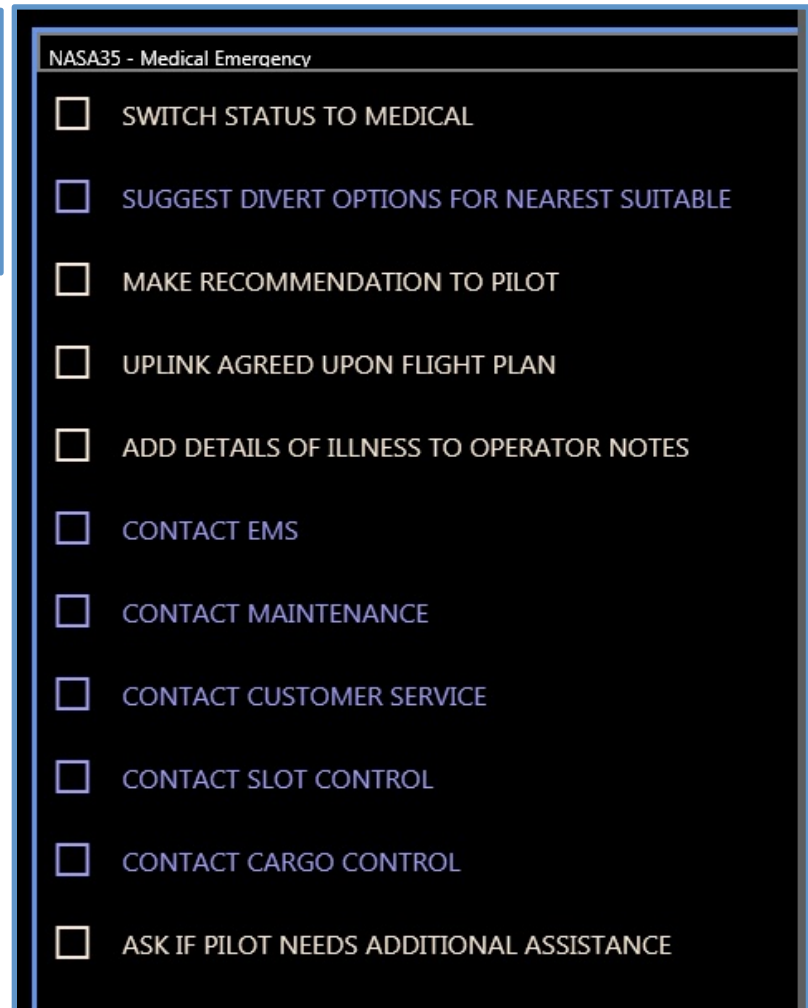


Building in HAT Tenets to the Ground Station

- Human-Directed
 - Operator calls “Plays” to determine who does what

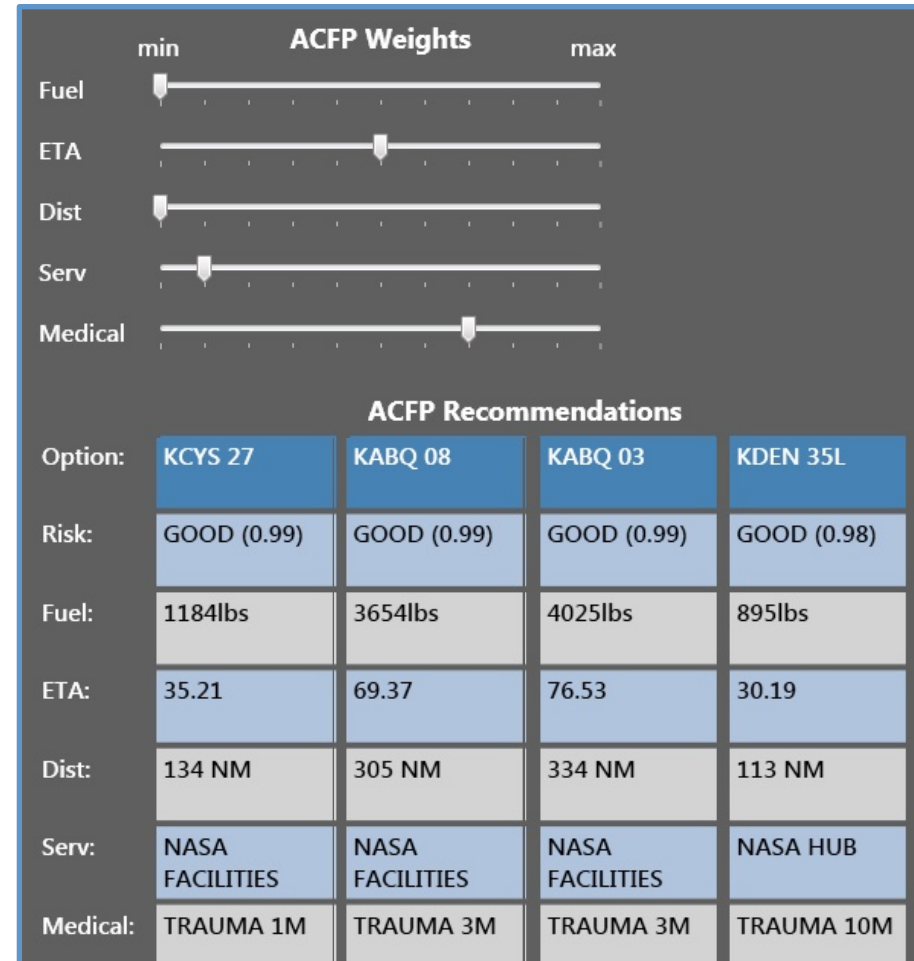


- A play encapsulates a plan for achieving a goal. It includes roles and responsibilities
 - what is the automation going to do
 - what is the operator going to do



Building in HAT Tenets to the Ground Station SAN JOSÉ STATE UNIVERSITY

- Transparency
 - Divert reasoning and factor weights are displayed
 - Numeric output from ACFP was found to be misleading by pilots. Display now uses English categorical descriptions.
- Bi-directional Communication
 - Operators can change factor weights to match their priorities



- Participants preferred the HAT condition overall ($M = 8.5$, $SD = 0.55$)
- HAT displays were preferred with regard to:
 - keeping up with operationally important issues ($M = 8.67$, $SD = 0.52$)
 - ensuring the necessary situation awareness for the task ($M = 8.67$, $SD = 0.52$)
 - integrating information from a variety of sources ($M = 8.67$, $SD = 0.52$)
 - reducing workload necessary for the task ($M = 8.33$, $SD = 0.82$)
 - efficiency ($M = 8.33$, $SD = 0.82$)
- Participants reported greater confidence that their diversion choice was appropriate in the HAT condition ($M = 7.83$, $SD = 1.47$) compared to the No HAT condition ($M = 6.33$, $SD = 2.07$; $t(5) = 4.39$, $p = .01$)
- ACFP was rated as useful ($M = 5.83$, $SD = 0.82$), particularly during emergency situations
 - *“Everything is easy and accessible in emergency situations. No need to consult many other programs to get various info.”*

- Supporting Bi-directional Communication
 - ACFP weights
 - improved automation's ability to handle unusual situations ($M = 7.83$, $SD = 1.60$)
 - were useful in making divert decisions ($M = 8.33$, $SD = 0.82$)
 - were liked ($M = 8.33$, $SD = 1.21$)
 - *"[the display] gave me the ability to see why, gave me control to change weights in variable(s)"*
- Building in Transparency
 - ACFP table
 - was helpful in making divert decisions ($M = 7.67$, $SD = 1.51$)
 - was liked ($M = 8.33$, $SD = 1.03$)
 - *"This [table] is wonderful... You would not find a dispatcher who would just be comfortable with making a decision without knowing why."*
- Creating an Operator Directed Interface with Plays
 - Electronic checklist
 - was liked ($M = 8.67$, $SD = 0.52$)
 - *"This electronic checklist was easier because it was right there on the screen and it eliminated a couple of steps"*

- Participants liked where we were headed with the HAT concept
 - Increased Situation Awareness
 - Reduced Subjective Workload
- Things we didn't get quite right
 - Participants didn't always understand what the goal of a play was
 - Annunciations: People liked them but thought there were too many
 - Voice Control: Did not work well. Need a more complete grammar, better recognition
- Things we didn't get to
 - Airlines hate divers. We need to put in support to help avoid them
 - Plays need more structure (branching logic)
 - Roles and responsibilities need to be more flexible
 - Limited ability to suggest alternatives

Where next?

- Running another part-task study with HAT features implemented on the flight deck
- Developing a software framework for creating HAT Agents

